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AUTHOR Pribyl, Paul F.
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ABSTRACT

This training unit on fire streams is part of a 17-unit course package written to aid instructors in the development, teaching, and evaluation of fire fighters in the Wisconsin Fire Service Certification Series. The purpose stated for the 8-hour unit is to provide the fire fighters with an understanding of the characteristics, use, and application methods of water in the control and suppression of fire. An instructor's guide sheet provides this information: introduction to the topic, instructor preparation, length of unit, methods of instruction, testing, equipment and facilities required, recommended visual aids, and references. Following a list of unit objectives, a lesson plan outlines the main teaching points and states the preferred teaching method, cites the reference and page number(s) where the information is to be found, and indicates the necessary handouts. Other contents in the unit include a unit quiz, answer key to the quiz, and handouts (graphs, student worksheets, informational material, and forms). (YLB)

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4802 Sheboygan Avenue, Madison, Wisconsin 53702
Robert P. Sorensen, Ph.D. State Director

FIRE SERVICE CERTIFICATION SERIES

UNIT FSCS-FF-10-80

FIRE STREAMS

FIRE SERVICE TRAINING

Simon L. Hertzler
Vocational Education Consultant

Paul F. Pribyl
Vocational Education Consultant

BUREAU OF PROGRAM DEVELOPMENT

George R. Kinsler
Bureau Director

Arnold H. Potthast
Chief Supervisor
Vocational Education

CE033907

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FIRE STREAMS

Prepared by:

Paul F. Pribyl, Consultant
Fire Service Training

INTRODUCTION

This unit is designed to provide the fire fighters with an understanding of the characteristics, use and application methods of water in the control and suppression of fire.

The candidates should become familiar with the requirements of various types of fires, and the type and size of fire stream for that particular fire. The candidate should be able to recognize the various types of nozzles, their characteristics, and the approximate flow that can be delivered from those nozzles. Upon completion of the unit, the candidates should be able to handle and control various hand lines and master stream appliances, using proper procedures in a safe and effective manner.

INSTRUCTOR PREPARATION

Carefully study the objectives to determine the goals that have been set for the candidates upon completion of the unit.

Review the lesson plans and if necessary, consult the references listed.

Develop suitable audio-visual aids, provide training area and necessary tools and equipment to effectively teach this unit.

LENGTH OF UNIT

Classroom	5 hours
Practice	2 hours
Evaluation and Testing	1 hour

METHOD OF INSTRUCTION

Illustrated Lecture and Demonstration

Suggested methods and techniques are listed under Instructors Notes on the lesson plan. For further information consult Fire Service Instructor Training , IFSTA #303 erd. ed., pp. 71-83.

TESTING

At the end of this unit a written quiz of five or more questions will be given.

EQUIPMENT AND FACILITIES REQUIRED

Classroom with necessary audio-visual and demonstration equipment.

100 feet of 2 1/2" hose and various 2 1/2" nozzles
100 feet of 1 1/2" hose and various 1 1/2" nozzles
Pumper equipped with necessary equipment
Deluge set with various tips and fog nozzles

REFERENCES

Hudiberg, E., Ed., Fire Stream Practices, #105, IFSTA, Stillwater, 5th ed, 1972 pp. 9-53, 131-150, 161-168

Hudiberg, E., Ed., Fundamental Principles of Science, #402 IFSTA, Stillwater, 3rd ed., 1967, pp. 36-42, 48

Hudiberg, E. and McCoy, C., Ed., Fire Service Practices for Volunteer Fire Departments, #201, IFSTA, Stillwater, 5th ed., 1971, pp. 129-134

Peige, J. Ed., Essentials of Fire Fighting, #200 IFSTA, Stillwater. 1st ed., 1977 pp. 161-179

OBJECTIVES:

All objectives in this unit are to be met according to the material contained in the International Fire Service Training Association Manuals #105 Fire Stream Practices, #201, Fire Service Practices for Volunteer Fire Departments ans #200 Essentials of Fire Fighting.

To satisfactorily complete this unit, the firefighter must attain a grade of 70 or higher on the written quiz and succesfully complete the practical skills examination.

NFPA STANDARD 1001

FIRE STREAMS

FIRE FIGHTER I

3-8 Fire Streams

3-8.1 The fire fighter shall define a fire stream.

3-8.2 The fire fighter, given the necessary resources, shall manipulate the nozzle so as to attack at least two live fires:including: a Class A fire and a Class B fire.

3-8.3 The fire fighter shall define water hammer and at least one method for its prevention.

3-8.4 The fire fighter shall demonstrate how to properly open and close a nozzle.

NFPA STANDARD 1001

FIRE STREAMS

FIRE FIGHTER II

4-8 Fire Streams

4-8.1 The fire fighter, given fire situations, for each situation shall:

(a) Identify the phase of burning
(2) Select the proper nozzle and hose size

4-8.2 The fire fighter shall identify characteristics of give types of fire streams.

4-8.3 The fire fighter, given fire ground situations, shall select and identify the proper adaptors or appliances.

4-8.4 The fire fighter shall identify several precautions to be followed while advancing hose lines to a fire.

4-8.5 The fire fighter shall identify three conditions that result in pressure losses in a hose line.

4-8.6 The fire fighter shall identify four special stream nozzles and demonstrate at least two uses or applications of each.

4-8.7 The fire fighter shall identify and explain foam making appliances used, and shall produce a foam stream from all types of foam making appliances used by the authority having jurisdiction.

4-8.8 The fire fighter shall identify three observable results that are attained when the proper application of a fire stream is accomplished.

4-8.9 The fire fighter, given the necessary resources, shall identify, select and assemble those items requierd to develop at least three types of fire streams.

COURSE: FIRE SERVICE CERTIFICATION SERIES

LESSON: FIRE STREAMS

EQUIPMENT NEEDED: SLIDE, OVERHEAD OR MOVIE PROJECTOR, SCREEN

TRAINING AIDS:TRANSPARENCIES, SLIDES, FILMS, TEXTS

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Essentials of Fire Fighting, IFSTA #200 pp. 161-182. Ref. P. 161 3-8 Fire Streams 3-8.1	A fire stream can be defined as a stream of water, or other extinguishing agent, after it leaves the fire hose and nozzle until it reaches the desired point in the desired configuration. The perfect fire stream can no longer be sharply defined since individual desires and extinguishing requirements vary. During the time a stream of water passes through space, it is influenced by its: velocity gravity wind and friction with air. The condition of the stream when it leaves the nozzle is influenced by: Operating pressures nozzle design nozzle adjustment and the condition of the nozzle orfice. Fire streams are intended to reduce temperatures and provide protection by one of the following methods. . By applying water directly to the burning material . By reducing high atmospheric temperature and by absorbing and/or dispersing hot smoke and fire gases from a heated area in a confined space. . By reducing the temperature over an open fire and thus permit a closer proximity with hand hose lines to effect extinguishment. . By protecting fire fighters and property from heat thru the use of fire streams as a water curtain.

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA #200 pp. 161-182

Ref. p. 161

Include this information

Water freezes at 32 Deg F.

boils at 212 Deg F.

Weighs 8.33 lbs per gallon

1 cubic foot of water contains 7.48 gallons

EXTINGUISHING PROPERTIES OF WATER

Water has the ability to absorb large quantities of heat.

Quantity of heat is measured in terms of British Thermal Units (Btu's).

A British thermal unit is defined as the amount of heat needed to raise the temperature of one pound of water one degree Fahrenheit.

At sea level, water boils and vaporizes into steam at 212 degrees Farenheit. Complete vaporization, however, does not happen the instant the water reaches the boiling point, because each pound of water will require approximately 970 Btu's of additional heat to completely turn it into steam.

When a fire stream is broken into small particles, it will absorb heat and be converted into steam more rapidly then it would be in a compact form because more of the water surface is exposed to the heat.

For example:

A one square inch cube of ice is dropped into a glass of water, it will take some time for the ice cube to absorb its capacity of heat because a surface area of only 6 square inches of the ice is exposed to the water.

Ref. p. 162

But if that cube of ice is divided into 1/8 inch cubes, and dropped into the water, a surface area of 48 square inches of the ice is exposed to the water. The finely divided particles of ice will absorb heat more rapidly.

This same principle applies to water in the liquid state.

Another chracteristic of water which is an aid to fire fighting is its expansion when converted into steam.

When water changes into steam it expands. The amount of expansion varies with the temperature of the fire area.

For example:

At 212 degrees F. a cubic foot of water expands approximately

1,700 times its original volume

At 500 degrees F.

2,400 times its original volume

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182

Ref. 162

EXTINGUISHING PROPERTIES OF WATER

At 1200 degrees F.

Approximately 2,400 times its original volume.

Steam expansion is not gradual but rapid, but if the room is already full of smoke and gases, the steam that is generated will displace these gases.

As the room cools, the steam condenses and allows the room to refill with cooler air.

The steam produced can also be an aid in fire extinguishment by smothering when certain types of materials burn.

Smothering is accomplished when the expansion of steam reduces oxygen in a confined space.

Ref. p. 163

Summing up the extinguishing properties of water, several characteristics which are extremely valuable from the fire extinguishing point of view can be listed.

. Water has a greater heat absorbing capacity than other common extinguishing agents.

. A relatively large amount of heat is required to change water into steam.

. The greater the surface area of the water that is exposed the more rapidly heat will be absorbed.

. Water converted into steam occupies several hundred times its original volume.

KINDS OF PRESSURE

The speed by which a fluid travels through hose is developed by pressure on that fluid.

Pressure, in a normal sense, may be defined as A FORCE OR ENERGY THAT MAY BE MEASURED IN POUNDS PER SQUARE INCH (psi).

An understanding of the terms static pressure, normal operating pressure, residual pressure and flow pressure is essential.

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182 Ref. 163	KINDS OF PRESSURE STATIC PRESSURE if the water is not moving, the pressure exerted is static. A water flow definition of static pressure could be as follows: STATIC PRESSURE IS STORED POTENTIAL ENERGY THAT IS AVAILABLE TO FORCE WATER THROUGH PIPE, FITTINGS, FIRE HOSE AND ADAPTERS. NORMAL OPERATING PRESSURE The flow of water through a distribution system to supply consumers continously flucuates during the day and night. A water flow definition of normal operating pressure can be as follows: NORMAL OPERATING PRESSURE IS THAT PRESSURE WHICH IS FOUND ON A WATER DISTRIBUTION SYSTEM DURING NORMAL CONSUMPTION DEMANDS. RESIDUAL PRESSURE The term residual represents the pressure left in a distribution system, at a specific location, when a quantity of water is flowing. A water flow definition of residual pressure could be as follows: RESIDUAL PRESSURE IS THAT PART OF THE TOTAL AVAILABLE PRESSURE THAT IS NOT USED TO OVERCOME FRICTION OR GRAVITY WHILE FORCING WATER THROUGH PIPE, FITTINGS, FIRE HOSE AND ADAPTERS. FLOW PRESSURE The forward velocity a water stream exerts a pressure that can be read on a pitot tube and gauge. A water flow definition of flow pressure can be as follows: FLOW PRESSURE IS THAT FORWARD VELOCITY PRESSURE AT A DISCHARGE OPENING WHILE WATER IS FLOWING. PRESSURE OR FRICTION LOSS A fire stream definition of friction loss could be as follows: FRICTION LOSS IS THAT PART OF TOTAL PRESSURE THAT IS USED TO OVERCOME FRICTION WHILE FORCING WATER THROUGH PIPE, FITTINGS, FIRE HOSE AND ADAPTERS.

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182

Ref. p. 163

PRESSURE OR FRICTION LOSS

An example of friction loss is the difference in pressure on a hose line between the engine and the nozzle.

Friction loss can be measured by inserting in-line gauges in a hose line.

The difference in the residual pressures between gauges when water is flowing through the hose will be the friction loss for the length of hose between the gauges for that rate of flow.

One point that should be considered in applying pressure on water in a hose line is that there is a limit to the velocity or speed at which the stream can travel.

If the velocity is increased beyond these limits, the friction becomes so great that the entire stream is agitated by resistance.

This agitation causes a point of turbulence called "critical velocity".

Beyond this point, it becomes necessary to parallel or siamese hose lines in order to increase the flow and reduce friction.

Ref. p. 164

4-8 Fire Streams

4-8.5

Certain characteristics of hose layouts affect friction loss and in order to reduce pressure loss due to friction as much as possible, the following should be observed.

. Check for rough linings in old hose

. Replace crushed couplings

. Eliminate sharp bends

. Use adaptors only when necessary

. Keep nozzles and valves fully open when possible

. Use proper size gaskets

. Use short lines as much as possible

. When flow must be increased, use larger hose or multiple lines.

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182

Ref. 164

PRESSURE LOSS OR GAIN BECAUSE OF ELEVATION

Since one (1) pound per square inch pressure is required to raise water in a fire hose or a pipe 2.3 feet, then 5 psi pressure will raise 5 x 2.3 or 11.5 feet.

Eleven and one-half or twelve feet is condidered as the average height of one story in a building, and approximately 5 psi is required to raise the water for every story.

If this additional pressure is not supplied, the nozzle pressure will be 5 psi per story less than it should be.

This condition is known as pressure loss because of elevation.

This principle applies equally for ground elevations since a hose line which is laid up a hill will lose 5 psi for each 11.5 feet of vertical rise.

By the same token, if the nozzle is lower than the pump, the nozzle pressure will be 5 psi greater for every 11.5 feet of vertical drop in elevation.

This condition is known as pressure gain because of elevation.

When there are no distinct floor levels, as in a grain elevator, the correction for elevation can be estimated at 1/2 psi per foot of elevation.

3-8 Fire Streams

3-8.3

WATER HAMMER

When the flow of water through fire hose or pipe is suddenly stopped, the resulting surge is referred to as WATER HAMMER.

Water hammer can often be heard as a distinct sharp clank, very much like a hammer strikinga pipe.

This sudden stoppage results in a change in the direction energy and this energy is instantaenously multiplied many times.

These excessive pressures can cause considerable damage to

. Water Mains
. Plumbing
. Fire Hose
. Fire Pumps

NOZZLE CONTROLS, HYDRANTS, VALVES AND HOSE CLAMPS SHOULD BE OPERATED SLOWLY TO PREVENT WATER HAMMER.

INSTRUCTORS NOTES

Ref: Essentials of Fire Fighting, IFSTA #200 pp. 163-182

Ref. pp. 164-165

4-8 Fire Streams

4-8.2

TEACHING POINTS

TYPES OF FIRE STREAMS

Fire streams may be defined in terms of size or volume.

A small stream can be considered a low volume stream which discharges less than 40 gpm including those fed by booster hose lines.

Hand line streams may be supplied by 1 1/2 to 2 1/2 inch hose.

Streams supplied by 1 1/2 inch hose will have capacities ranging from:

40 to 125 gpm

While those fed by 2 1/2 inch hose will discharge from

125 to 300 gpm

Nozzles with flows in excess of 300 gpm are not recommended for hand lines.

A master stream is a large volume stream which discharges more than 300 gpm, and is usually fed by two or more hose lines siamesed into a master stream device.

In any classification , the stream may be either

solid or spray pattern

The following table shows the standard diameters of rubber-lined fire hose identified with flows which they are capable of carrying without excessive friction losses when hose lengths do not exceed 600 feet.

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182

Ref. pp. 165

4-8 Fire Streams

4-8.2

Refer to Handout #1

NOMINAL HOSE DIAMETER IN INCHES		MAXIMUM EFFICIENT WATER CAPACITY US GPM
1		30
1-1/2		100
2-1/2		300
2-3/4		400
3		500
3-1/2		750
4		1000
5		1700
6	600 Feet of Line	2500

Ref. p. 165

BROKEN STREAMS

A broken stream may be a solid stream that has been broken into coarsely divided drops for the purpose of protecting exposed buildings.

A solid stream may become a broken stream because of reacting forces, and it may be desirable that a stream break near the fire to sprinkle the burning material.

Other means may be employed to produce broken streams such as:

rotary distributor nozzles
flat spoon-bill nozzles

or

by directing two solid streams together in midair.

Regardless of the method used to produce a broken stream, such streams have a definite purpose in fire fighting, particularly when a water curtain is desired.

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182

Ref. p. 165

4-8 Fire Streams

4-8.2

CHARACTERISTICS OF BROKEN FIRE STREAMS

It is difficult to draw an exact line between a broken stream and a fog stream except that a fog stream is usually produced in definite patterns and finer particles.

A broken stream should cover the most space possible and yet afford enough heat absorbtion to extinguish the fire.

If it is possible to get the nozzle close to the fire, the breaking of the stream may be done at the nozzle.

These broken streams are useful when fighting a basement fire through the floor above or when fighting a fire in a partition.

The volume of a broken stream should be comparable to that of a solid stream.

Where borken streams are used, water damage is not genrally given as much concern as extinguishing the fire, since considerable water is projected over the general area

A WATER CURTAIN is a fire stream which takes, as nearly as possible, the shape of a curtain or fan between a fire and other combustible material.

A water curtain is sometimes desirable to protect fire fighters from heat.

The fundemental requirement of a water curtain is to protect or shield an exposure from fire.

The curtain must cover a wide area and be reasonably heavy to fill this requirement.

Tests have indicated that a water curtain between the fire and combustible materials is not as effective as the same amount of water flowing over the surface of the combustible material.

It is, therefore, better to direct fire streams upon exposed surfaces rather than to establish a water curtain between a fire and an exposure.

Ref. p. 165

FOG OR SPRAY STREAMS

It is unfortunate that the term "fog" was ever used to describe a jet of water that is divided into drops with a definite shape or design.

Actually the term "fog" means condensed water vapor that is much like a cloud and it does not describe the fast moving jet of water drops from a fire fighting nozzle.

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182 Ref. p. 165 Ref. pp. 166-169	FOG OR SPRAY STREAMS The terms "vapor" and "spray" have also been used interchangeably to describe this type of fire stream. The terms "fog nozzle" and "fog Stream" are, however, commonly used in the fire service as acceptable descriptive terms.
5-4 Fire Streams 5-4.1 Refer to Handout #2	There are three types of fog nozzles: . High Pressure . Fixed Pattern , Adjustable Pattern
4-8 Fire Streams 4-8.2	APPLYING FOG STREAMS The use of water fog in fire extinguishment requires a special technique of operation. The mere fact that firefighters have a good fog nozzle which supplies a protective curtain doe not enable them to advance carelessly into a heavily charged area and expect to do an effective ventilating and extinguishing job. When water fog is used for ventilating and extinguishing purposes, the degree of effectiveness depends upon how, where, and when the fog stream is applied. As the fog stream is projected, it should be "worked", that is, it should be directed in such a manner as to cover the greatest possible area. Tests have shown that a circular motion of the nozzle is usually more satisfactory. REMEMBER !! IT IS ESSENTIAL FOR A FOG STREAM TO DELIVER A VOLUME OF WATER WHICH IS SUFFICIENT TO ABSORB HEAT MORE RAPIDLY THAN IT IS GENERATED.
Ref. p. 165	SOLID STREAMS The fire service requires a fire stream nozzle to produce a specific pattern of water jet in order to perform a specific function. The solid stream nozzle is designed to produce a stream as compact as possible with little shower or spray. Its ability to reach areas that might not be reached by other mediums has established the solid stream as necessary to the fire service.

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182

4-8 Fire Streams

4-8.2

Ref. p. 165, 169-170

SOLID STREAMS

Modern constant flow or constant gallonage fog nozzles will, however, produce a straight stream which is substantially equivalent to a solid stream.

The extreme limit at which a solid stream of water can be classified as a good stream cannot be sharply defined and is, to a consideable extent, a matter of judgement.

It is difficult to say within five feet, or in some instances even ten feet, just exactly where the stream ceases to be good.

Any observations or recordings that may be made to classify solid stream in turn reflect the characteristics of the condition of the nozzle.

Observations and tests, covering the effective range of fire streams, have classed as good those streams which at the point of breakover have the following required physical characteristics:

- A stream that at the point of breakover has not lost continuity by breaking into showers of spray.
- A stream that up tp the point of breakover appears to shoot nine-tenths of the whole volume of water inside a circle 15 inches in diameter and three-quarters of it inside a 10-inch circle, as nearly as can be judged by the eye.
- A stream that probably would be stiff enough to attain in fair condition the height reauired even though a fresh breeze is blowing.

Water from a nozzle producing a jet to conform with these characteristics would be thrown much farther than the breaking point, but beyond this point, it tends to be in the form of heavy rain which is easily carried away.

Ref. p. 170

FLOW CAPACITY OF SOLID STREAMS

The rate of discharge of a fire stream is measured in gallons per minute (gpm).

Flow from a nozzle is largely determined by the velocity of the stream and the size of the discharge opening.

These two factors are influenced by other forces and, for this reason, they will be considered separately.

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182

4-8 Fire Streams

4-8.2

FLOW CAPACITY OF SOLID STREAMS

VELOCITY

Velocity is the speed of an object in a given direction.

In relation to a stream of water, the speed is developed by pressure upon the water.

Since water is practically incompressible, the water will flow at a certain rate of speed.

Gallons per minute flow capacity of a nozzle increases by four times when the diameter of the discharge opening is doubled.

A nozzle of a certain size will discharge just so much water at a definite stream velocity.

To increase the discharge, a firefighter must either use a larger nozzle or increase the stream velocity.

For example:

5-4 Fire Streams

5-4.2

TIP SIZE	50psi GPM	TIP SIZE	65psi GPM
3/4 inch	100	3/4 inch	150
7/8 inch	150	7/8 inch	200
1 inch	200	1 inch	250
1-1/8 inch	250	1-1/8 inch	300
1-1/4 inch	300	1-1/4 inch	350

Refer to Handout #7

One basic rule concerning flow capacity of a solid fire stream states:

THE NOZZLE TIP SIZE SHOULD NOT BE LARGER THAN ONE-HALF THE DIAMETER OF THE HOSE.

FOG NOZZLES AT 100 psi.

3/4" or 1"	12 to 32 gpm
1-1/2"	30 to 125 gpm
2-1/2"	120 to 350 gpm

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182

4-8 Fire Streams

4-8.2

Ref. p. 170

EFFECTIVE REACH OF A SOLID STREAM

Just as a solid fire stream will deliver a definite discharge under given conditions, it will also travel a predetermined distance from the nozzle.

The reach of a solid fire stream is the distance which a stream can be effectively thrown from a nozzle.

Two forces, gravity and friction of the air, tend to decrease this reach.

These opposing forces must be overcome by the forward velocity and the volume of the stream.

Since the stream is beyond mechnical control after it leaves the nozzle, its speed while passing through space and the distance it will travel is determined by these two factors.

If the stream is encased within a pipe and put under 50 psi pressure at the base of the pipe, the water will fill to the height of 115 feet.

In other words, if one psi will raise water in a pipe 2.3 feet, then 50 psi will raise the water 115 feet.

If the same stream of water is not encased in a pipe but is directed vertically into the air, the performance changes.

EFFECTIVE RANGE OF SOLID FIRE STREAMS

Refer to Handout #3

Showing the distance in feet from the nozzle at which streams will do effective work with a moderate wind blowing. With a strong wind, the reach is greatly reduced.

After leaving the tip, the stream tends to hold its shape for a considerable distance and then begins to flare out and break into drops.

The broken drops of water soon lose their momentum and fall to the ground.

This breaking away continues until only the inner part of the column reaches the maximum height.

The friction of the air on the outer surface of the water column breaks the stream, and the force of gravity pulls the drops to the ground.

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182

Ref. 170-173

Ref: Fire Stream Practices IFSTA, #105 pp. 138-142

HANDLING FIRE STREAMS

One Person Method
(1-1/2 hose)

A hose line and the nozzle must be kept under control at all times.

When one person is required to handle a 1-1/2 inch hose line and nozzle, some means must be provided for bracing and anchoring the hose line.

The fire fighter should hold the nozzle with one hand and with the other hand hold the hose just back of the nozzle.

Ref. #200 p. 170
#105 p. 138

The hose line should be straightened for at least 10 feet behind the fire fighter with the nozzle and the person holding the nozzle should face the direction in which the stream is to be projected.

Permit the hose to cradle against the inside of the closest leg and brace or hold it against the front of the body and hip.

Anchor the hose to the ground or floor by placing the foot of the supporting leg upon the hose.

If the stream is to be moved or directed at an excessive angle from the center line, close the nozzle, straighten the hose, and resume the operation position.

One Person Method
(2-1/2 inch hose)

Ref. #200 p. 171
#105 p. 140

Whenever a fog or solid stream nozzle is used connected to a 2-1/2 inch fire hose, a MINIMUM of two and preferably three, fire fighters should be employed.

Fire fighters may, however, find that they are alone with a 2-1/2 inch charged hose line that needs to be used.

The fire fighter should secure slack hose from the line, form a loop over the line about two feet back of the nozzle, then sit where the hose crosses and direct the stream.

This method does not permit much maneuvering of the nozzle, but the nozzle can be operated from this point until help is available.

If the operation is to be of considerable duration and other equipment or personnel is not available, lash the hose where it crosses to permit easeof operation, safely.

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182

Ref: Fire Stream Practices IFSTA, #105 pp. 138-142

Ref. p. 170 #200
p. 139

HANDLING FIRE STREAMS

Two Person Method
(1-1/2 inch hose)

The two-person method of handling a nozzle on a 1-1/2 inch hose line should be used whenever possible, because it provides a greater degree of safety than the one-person method.

The two-person method is usually necessary when the nozzle needs to be advanced.

One fire fighter holds the nozzle with one hand and with the other holds the hose just back of the nozzle. The hose line is then rested against the waist and across the fire fighters hip.

The second fire fighter takes a position on the opposite side of the hose about 3 or 4 feet back. The hose is held with both hands and rests againt the waist and across the hip of the fire fighter.

An important function of the second fire fighter is to keep the hose straight behind the fire fighter with the nozzle.

Ref. P. 171-172 #200
pp. 140-141 #105

Two Person Method
(2-1/2 inch hose)

When only two fire fighters are available to handle a nozzle on a 2-1/2 inch hose line, some means of anchoring the hose must be provided because of the kickback.

One method is for the fire fighter with the nozzle to hold it with one hand and the hose, just back of the nozzle with the other hand, with the hoseline resting against the waist and across the hip.

The second fire fighter, whose position is about 4 feet back of the person with the nozzle, places the closest knee on the hose line and acts as an anchor.

In this position, the fire fighter should be kneeling on one knee and have both hands on the hose line near the other knee.

This position prevents the hose from moving back or to either side and should the hose try to come back or up, the second fire fighter is in a position to push it forward.

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182 Ref: Fire Stream Practices IFSTA, #105 pp. 138-142 Ref. pp. 171-172 #200 pp. 140-141 #105	HANDLING FIRE STREAMS Two-Person Method (2-1/2 inch hose) Another two-person method utilizes rope hose tools or spanner belts to assist in anchoring the hose. The fire fighter at the nozzle loops a rope hose tool of spanner belt around the hose a short distance from the nozzle and places the large loop over the OUTSIDE SHOULDER. The fire fighter holds the nozzle with one hand and the hose just back of the nozzle with the other hand. The hose is then rested against the fire fighter who leans slightly toward the nozzle to hold back some of the pressure. The second fire fighter who is about 4 feet back of the first fire fighter follows the same procedure.
Ref. p. 172 #200 Ref. p. 142 #105	Three-Person Method (2-1/2 inch hose) Handling of a nozzle on a 2-1/2 inch line can be more easily done by three fire fighters. There are some differences of opinion as to the location of the fire fighters providing backup to the person with the nozzle. Some prefer a fire fighter directly behind the person with the nozzle and the third fire fighter kneeling on the hose behind the first two. Others feel that the second and third fire fighters should both be kneeling on opposite sides of the hose and anchoring it behind the person with the nozzle. Still another way is to alternate the three fire fighters on either side of the hose using rope hose tools or spanner belts to anchor the line and remaining on their feet. It is suggested that all of the methods be tried by the individual departments with them selecting the method that best meets their needs and/or standard operating procedure.

INSTRUCTORS NOTES

Ref: Essentials of Fire Fighting, IFSTA #200 pp. 161-182

Ref: Fire Stream Practices IFSTA, #105 pp. 142-143

Ref. p. 172 #200
Ref. p. 143 #105

4-8 Fire Streams

4-8.4

TEACHING POINTS

MANEUVERING THE NOZZLE

A fire stream nozzle should, in most situations, be kept moving from place to place in order to cover more area.

This procedure is sometimes called "working the nozzle" and tends to absorb more heat and give the fire fighter on the nozzle added protection.

Nozzles can be maneuvered to the left and to the right of the anchor point approximately 45 degrees without undue stress upon the fire fighters.

Maneuvering the line beyond 45 degrees could cause a kink in the line which may upset the fire fighters manning the line.

Should the fire stream need to reach a point outside these limits, the fire fighter with the nozzle should partially close it and direct the backup fire fighters to reposition the line insuring there are no bends in the line for a distance of 6 to 8 feet behind the anchor point.

If a nozzle becomes to difficult to handle, the stream should be partially shut down until the hose line can be straightened or additional help can be summoned.

If the line gets away from the fire fighters holding it, run ahead of the line rather than be struck by the backlash of the nozzle. If you can SAFELY DO SO. Fall on the loose line working your way to the nozzle and shut it off.

Wild lines can also be controlled by kinking the hose or the use of a hose clamp and naturally be shutting down the pump at the apparatus.

NEVER LEAVE A PERSON ALONE WITH THE NOZZLE ON A CHARGED LINE UNLESS IT IS ABSOLUTELY NECESSARY AND ADVISE THEM OF THE SITUATION.

There are several precautions which should be followed when advancing hose lines to a fire.

Fire Fighters should avoid such hazards as:

fences- sharp objects that could damage the hose

or anything that might bind, catch or cramp the hose while lines are being advanced.

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182

Ref: Fire Stream Practices IFSTA, #105 143-146

Ref. 173-174 #200
Ref. p. 143

4-8 Fire Streams

4-8.4

ADVANCING THE NOZZLE

Before fire fighters advance a hose line and nozzle into a dangerous area, they should have the proper protective clothing and breathing equipment.

Many fire fighters, under the stress of excitement, tend to forget their own welfare and thoughtlessly enter dangerous areas without protection.

Since fire fighters are responsible for the welfare of the citizens, it is also their responsibility to protect themselves again the possibility of harmful gases so that their work may be carried out as rapidly as possible.

Some of the more essential precautions are listed for your protection and safety:

. Self-contained protective breathing apparatus should be worn to provide self-protection against toxic gases that may be encountered. NOTE WHEN DEALING WITH PESTICIDES OR OTHER POISONS REQUIRE THAT POSITIVE PRESSURE DEMAND BREATHING APPARATUS BE WORN IN ADDITION TO PROPER PROTECTIVE CLOTHING FOR THE HAZARD ENCOUNTERED.

. When advancing through a smoke-filled area, fire fighters should feel their way. This will avaoid their falling through burned floor areas, elevator shafts, pits or stairways.

. Feeling the walls or contents with the hands will help to guide fire fighters around obstacles when they are advancing through smoke-filled areas.

. When it is necessary to enter an atmosphere containing an oxygen deficiency, some approved type of self-contained protective breathing apparatus should be provided and worn

. When fire fighters are entering an atmosphere containing noxious gases, such as ammonia, sulfur dioxide, carbon dioxide, freon, and others, the same precaution should be taken and the equipment worn.

. When entrance is made, fire fighters should advance in pairs or groups and NEVER without a charged hose line.

. If necessary to retreat, close the nozzle and follow the hose line to the outside of the building.

. The value of water fog in dissolving and settling gases of combustion and in expelling smoke should not be minimized. Water fog should be used as a safety precaution when fire fighters are entering a highly heated area.

INSTRUCTORS NOTES

Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182

Ref: Fire Stream Practices IFSTA, #105 pp. 143-146

3-8 Fire Streams

3-8.4

TEACHING POINTS

SAFETY FACTORS IN HANDLING THE NOZZLE

It is most important for fire fighters to be knowledgeable of safety factors for handling fire stream nozzles.

Most important of these is their ability to judge when additional manpower is needed.

Several preliminary precautions are offered that should be practiced before the actual application of water takes place . These precautions are:

. The nozzle should be checked for proper gasket, for operations of control valves, and for dents or obstructions that might interfere with the proper flow of the fire streams (periodic inspection)

. The nozzle should be kept closed while the fire fighters are:

a. making up hose lines
b. hoisting or advancing lines
c. changing operation positions

. The nozzle should never be dragged or dropped. If tips are removed, they should be carried in the fire fighters clothing and returned to the apparatus.

. Trapped air should be released through the nozzle, and the stream checked or fog pattern properly set before fire fighters enter to attack a fire.

. The flow of water should be controlled by slowly opening and closing all nozzles, valves and clamps.

Slow operation prevents sudden surges of pressure upon t hose and equipment and is a precaution against injury to fire fighters and damage to equipment.

. When two fire fighters or more are manning a line be sure to have the second and third fire fighters placed on the line in such a manner that they will relieve the person on the nozzle of the reaction.

. FOR YOUR SAFETY If a nozzle should get out of control, the fire fighter(s) should step in front of the nozzle to prevent being struck by it.

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182

Ref: Fire Stream Practices IFSTA, #105 pp. 7, 147-149

3-8 Fire Streams

3-8.2

REQUIREMENTS FOR EXTINGUISHING STRUCTURAL FIRES

Building fires may be divided into fires which are primarily:

- confined within the walls, roof and floor of a structure or building

and

- fires within a building which have ventilated themselves to the extent that they are free burning into the open.

Each of these conditions presents a different problem and fire fighting situation.

When fire is confined within the walls, ceiling and/or roof of a room or building, the intense heat, smoke and fire gases will also be confined in the burning space.

The confined building fire presents a situation that requires careful consideration to prevent further damage and to effect extinguishment.

This type of fire may be considered in three different phases for the purpose of determining requirements.

First Phase - Incipient or Begining

Second Phase - Free Burning

Third Phase - Smoldering

The major difference between the three phases is from the standpoint of ventilation practices.

Knowledge of these phases is also useful from a fire extinguishment point of view.

INCIPIENT PHASE OF FIRE usually requires a direct applicatio of water at the base of the fire to reduce the temperature of the fuel below its ignition point.

The amount of heat being generated will increase as the fire progresses.

Although the flame temperature will be well over 1,000 degrees Farenheit, the room temperature may only be slightly increased.

THE MAJOR CONSIDERATION IS REACHING THE FIRE.

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182

Ref: Fire Stream Practices IFSTA, #105 pp. 7, 147-149

Ref. p. 174-175

3-8 Fire Streams

3-8.2

4-8 Fire Streams

4-8.1

Ref. p. 175

REQUIREMENTS FOR EXTINGUISHING STRUCTURAL FIRES

In the SECOND or FREE BURNING PHASE, the area will be extremely hot.

A confined building fire in the second phase requires a reduction of atmospheric temperatures to livable conditions so that fire fighters can enter and extinguish the main body of fire.

Once the temperature is reduced, firefighters may enter and extinguish any remaining fires by direct application but protective breathing equipment will be required for the safety of those entering.

In the THIRD or SMOLDERING PHASE, the heated area will be filled with hot smoke and fire gases.

So far as the fire gases and smoke are concerned, firefighters could enter with protective breathing equipment, but the heat would be unbearable.

Experiments and tests have shown that a building containing a third phase fire may be made tenable by applying water fog into the most highly heated upper levels.

The heat will convert the finely divided particles of water into steam thereby reducing the temperature in the space.

The expansion of steam will further force smoke and gases from the space.

In this phase:

. the heat must be reduced

and

. the smoke and gases must be displaced

before fresh air can be admitted.

An OPEN OR NONCONFINED BUILDING FIRE is one which has burned to the outside, releasing heated smoke and gases.

The entire building may be involved and these open fires require-long range operations.

The intense radiated heat from an open fire makes it difficult to apply water directly at the base of the fire.

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182

Ref: Fire Stream Practices IFSTA, #105 pp. 147-148

REQUIREMENTS FOR EXTINGUISHING STRUCTURAL FIRES

A large volume of water is usually required to control and extinguish the open or nonconfined building fire, which may require straight streams and long-range fog streams.

This type of fire also requires careful consideration of exposures, with equal consideration for fire streams to protect them.

Ref. p. 175-176

A CONFINED STRUCTURAL FIRE

The conditions that may be found in a confined structural fire and the phases of its development have again been outlined by the Analysis Table, from which we may list the important factors of applying fog streams.

Refer to Handout #4

Some of the important factors are as follows:

1. The fog stream should be projected into the hottest space, which may be the upper levels if the fire has burned for a considerable duration.

2. If a short-reach, wide-angle fog pattern will cover the area, it should be projected upward into the heated area and worked in a circular motion for complete coverage.

3. If the area is so large it cannot be reached by the short-reach wide-angle fog pattern, a long-reach fog pattern should be used to carry the droplets into the hottest space and the nozzle worked back and forth for complete coverage.

4. The number of fog streams to use should be determined by the cubic foot area involved and the volume of the nozzles.

5. Enough water fog must be applied to absorb the heat faster than it is being generated.

6. One or more extra lines should be supplied for auxiliary use. They may be used to extinguish the remaining fire.

7. The officer in charge should watch for:

   First - smoke
   Second - smoke and condensed steam
   Third - condensed steam

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA, #200

Ref: Fire Stream Practices Ifsta, #106 pp. 147-148

Ref. p. 176

3-8 Fire Streams

3-8.2

A CONFINED STRUCTURAL FIRE

8. A fog stream should be shut off as soon as smoke and gas have been displaced by condensed steam.

9. If the atmosphere is still too hot, a second burst of water fog may be required.

10. All spot fires may be extinguished by direct application.

11. When the application of water fog is made through an opening into a building, the firefighters should keep well out of line with the opening to protect themselves from the expulsion of heated gases and steam back through the opening.

REQUIREMENTS FOR EXTINGUISHING FLAMMABLE LIQUID FIRES

Flammable liquids produce fuel vapors under varying circumstances according to the volatility of the liquid.

The lowest temperature at which a solid or a liquid will give off enough vapors to ignite momentarily is known as its FLASH POINT.

Gasoline, for example, gives off flammable vapors as low as 45 degrees below zero Fahrenheit.

Kerosene starts giving off flammable vapors somewhere between 100 and 150 degrees Fahrenheit.

Their ignition temperatures range from 536 to 853 degrees Fahrenheit for gasoline

and from 410 to 444 degrees Fahrenheit for kerosene.

With this information, one can see that it may be difficult to adequately reduce the temperature of these or other flammable liquids with water fog and that extinguishment of the fire may depend on how the water fog is applied.

Even though the fire is extinguished, there is a constant danger of reignition if any materials near the liquid retain a temperature above the ignition temperature of the flammable liquid.

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182

Ref: Fire Stream Practices IFSTA, #105 pp. 149-150

3-8 Fire Streams

3-8.2

REQUIREMENTS FOR EXTINGUISHING FLAMMABLE LIQUID FIRES

To assure extinguishment without danger of reignition, firefighters must blanket the fuel with some material such as foam or an inert gas.

Extinguishment of heavy and medium oils may be accomplished by bombarding the surface of the oil with a long reach fog stream to produce an emulsion which will not burn.

As the water is vaporized, it takes heat from both the oil and flames.

The increase in volume when the water is converted into steam dilutes the layer of flammable vapor above the oil.

When the proportion of water vapor (steam) becomes high enough, the resulting mixture of oil vapors, inert gases, and active oxygen becomes too lean to burn and the flames are extinguished.

When applied to alcohol, acetone and other water-soluble flammable liquid fires, water fog may extinguish the fire and also lessen vaporization by mixing with the liquid.

It should be apllied into the fire to be converted into steam and then allowed to settle upon and into the liquid.

All surrounding metal and heated materials should be thoroughly cooled to guard against reignition.

The low flash point of gasoline permits large volumes of flammable vapor to be emmitted at ordinary temperatures, which in turn makes control of these fires more difficult.

If the gasoline is confined, a short-reach fog applied by means of an applicator is usually the best means of application in order to get the water fog over the liquid.

If this method is not practical or possible, long-reach or short-reach fog may be directed into the flame just above the liquid.

Firefighters should sweep the stream back and forth and use more than one fog stream to facilitate control.

All materials in and near the liquid must be thoroughly cooled if complete extinguishment is to be maintained.

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182 Ref: Fire Stream Practices IFSTA, #105 pp. 149-150 Ref. p. 177 3-8 Fire Streams 3-8.2	REQUIREMENTS FOR EXTINGUISHING FLAMMABLE LIQUID FIRES The surest method to extinguish a flammable liquid fire is to blanket the burning area with foam or other noncombustible substances to stop the production of flammable vapors. Water will not usually accomplish this purpose since it is heavier than gasoline and the gasoline floats on top. Aboveground storage tanks for flammable liquids present an explosion hazard when exposed to heat. If the tanks lie horizontal to the ground, the ends should be avoided when the tanks are approached because tanks are most likely to rupture at the end seams. It is usually safertto apply volumes of water directly to the upper portion of tne tanks while standing to one side.
4-8 Fire Streams 4-8.1 Ref. p. 177	SELECTING THE FIRE STREAM When a fire company arrives at a fire, the officer in charge should previously have formed a mental impression of certain probabilities and this impression should be based on the known facts that are available through pre fire planning. A fire of major proportions usually presents complications and rapidly changing events. A quick survey and analysis should be made and the type of fire streams that will best meet the requirements of the situation should be selected. A SIZE UP is an estimation or an evaluation of a condition from which an opinion or judgement can be formed. The purpose of any size up is to determine the action that is necessary to cope with a situation. The ultimate objective in fire fighting is to confine and extinguish fire, and the selection of the proper fire stream or streams is vitally essential to fulfill this objective.

INSTRUCTORS NOTES

Ref. Essentials of Fire Fighting, IFSTA, #200 pp.161-182

Ref: Fire Stream Practices IFSTA, #105 pp. 131-135

Ref: Fire Department Facilities,Planning and Procedures, IFSTA pp. 100-103

4-8 Fire Streams

4-8.1

Ref. p. 177

TEACHING POINTS

PRE-FIRE PLANNING

Pre-fire planning is a function which involves several factors, such as:

Time

Surveys

Analysis

The extent to which fire streams are involved in pre-fire planning is discussed in IFSTA Manual No. 302, "FIRE DEPARTMENT - Facilities, Planning and Procedures.

Nozzles may be carried attached to hose lines as a unit assembly or as preconnected lines.

In either event, selecting nozzles and stream are a part of pre-fire planning.

They are also a result of considerable advanced observations and fire ground demonstrations.

Each company officer and other members of the company should be aware of:

. the nozzles available

. how they are carried

. the flow of each nozzle

. the desired nozzle pressure

nad the friction loss in appliances including wyes, siameses and master stream devices.

The information can be found by field tests.

CONSIDERING THE FIRE

The situation in which a fire is found should govern the type of fire streams and the positions for attack.

As the burning process progresses, heat control and fire extinguishment become more difficult because of the magnitud of the fire and the quantity of heat that is produced.

Whenever a fire is progressing and is not checked by the extinguishing agents being used, additional extinguishing agents must be provided to increase the attack and permit more aggressive action on the fire.

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182

Ref: Fire Stream Practices IFSTA, #105 pp. 131-135

4-8 Fire Streams

4-8.1

Ref. p. 177

CONSIDERING THE FIRE

Whenever adequate volume and correct methods are employed at advantageous points of attack and the heat is absorbed faster than it is being generated, a noticeable headway will be observed.

The three-position approach to fire fighting has fundamentally been a good practice for many years.

These positions are at:

1. exposures
2. avenues of fire spread
3. point of origin

Fires of any magnitude must be attacked from these three positions of approach if control and extinguishment are to be accomplished.

The primary objective of an initial decision is to get things started according to standard operating procedures.

It may be necessary to apply fire streams at certain places or areas before a complete decision can be made on an overall course of action.

It is often impossible to predict which operation should be performed first, because many operations might be performed simultaneously.

It is obvious that some immediate application of water is necessary.

Fire stream nozzles for an immediate attack are usually selected prior to a response to a fire.

STREAMS TO PROTECT EXPOSURES

The need for exposure protection and the way in which exposures become a part of a fire attack should be considered.

Exposures, avenues of fire spread and points of origin have been established as the three positions from which a fire attack must be launched if control and extinguishment of the fire are to be accomplished.

INSTRUCTORS NOTES

Ref: Essentials of Fire Fighting, IFSTA #200 pp. 161-182

Ref: Fire Stream Practices IFSTA, #105 pp. 131-135

4-8 Fire Streams

4-8.1

Ref. p. 178

Additional information concerning exposure protection and the fundamental factors that contribute to the spread of fire can be obtained from the NFPA Fire Protection Handbook.

TEACHING POINTS

STREAMS TO PROTECT EXPOSURES

When a small structure, such as an ordinary dwelling, is involved, an exposure attack may be made with fire streams from small hose lines.

Larger buildings may require exposure protection with large hand streams or even master streams and water curtains.

When a fire has penetrated an exposed building, an attack must be carried into the interior in addition to an attack upon the opening through which the fire extended.

All roofs, windows and doors that are located on the exposed side of a building should be protected with adequate fire streams.

STREAMS AT AVENUES OF FIRE SPREAD

Fire can spread throughout a burning building by one or more of four methods.

These methods are commonly referred to as:

1. Conduction
2. Radiation
3. Convection
4. Direct Flame Contact

These four principles were discussed in Unit 3, Fire Behavior of this series.

Fire spreads throughout a building by a:

Horizontal

Vertical

and

Downward Extension process.

From the standpoint of fire attack, places that are vunerable to fire spread are:

False Ceilings	Attics
Corridors	Vertical Openings
Cock Lofts	Horizontal Openings

Spaces between floors, ceilings and walls
These areas and places should be seriously considered when a fire stream is selected.

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182

Ref: Fire Stream Practices IFSTA, #105 pp. 131-135

4-8 Fire Streams

4-8.1

Ref. p. 178

STREAMS AT AVENUES OF FIRE SPREAD

Some of the ways by which this extension is possible are listed: HORIZONTAL EXTENSION

...Through wall openings by direct flame contact or by convected air currents

...Through open space by radiated heat or by convected air currents

...Through corridors, halls, or passageways by convected air currents, radiation and direct flame contact

...In all directions by explosion or flash burning of fire gases, flammable vapors or dust

...Through walls and interior partitions by direct flame contact

...Through walls by conduction of heat through beams, pipes, ducts, or other objects that extend through walls

VERTICAL EXTENSION

...Through stairwells, elevators and shafts by direct flame contact or by convected air currents

...Through partitions and walls and upward between walls by direct flame contact and convected air currents

...Through windows or other exterior openings by convection into upper floors

...Through ceilings and floors by conduction of heat through beams, pipes or other objects that extend from floor to floor

...Through ceilings and floors by direct flame contact

DOWNWARD EXTENSION

...Through floors and ceilings by direct flame contact

...Through floor and ceiling openings where sparks and burning material fall through beams, pipes and other objects that extend from floor to floor

...By the collapse of floors and roofs

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA, #200

Ref: Fire Stream Practices IFSTA, #105 pp. 131-135

Ref. p. 178

4-8 Fire Streams

4-8.1

STREAMS AT POINT OF ORIGIN

The POINT OF ORIGIN of a fire is sometimes quite visible and easily identified, but at other times its location may be completely concealed and difficult to determine.

The point of origin will usually be located where the most intense fire is present, unless the fire has extended to more highly flammable materials or an explosion has caused a rapid extension of the fire.

The value of locating the point of origin and intense burning is to enable a concentrated attack with fire streams at that point.

Enclosed fires sometimes present a situation where the point of origin can be attacked before a fire has had a chance to extend to other areas.

In this event, an attack at avenues of fire spread and at exposures may not be necessary although hose lines and fire streams should, in most instances, be provided at these two positions.

Exisiting conditions sometimes cause fires to spread so rapidly that it is not only desirable but absolutely essential to advance fire streams to avenues of spread and at exposures before the point of origin can be reached.

EMPHASIZE the importance of utilizing a large enough line to meet this requirement.

When the attack is made at the point of origin IT IS ESSENTIAL THAT THE RATE OF FLOW OF THE ATTACK LINES BE SUFFICIENT TO REDUCE ACCUMULATED HEAT AND HEAT PRODUCTION.

Ref. p. 179

In an enclosed area that is fully involved, a rule of thumb formula can be used to estimate the rate of flow necessary to control the fire.

This formula suggests one gallon per minute for each 100 cubic feet of enclosed space as the minimum rate of flow.

$$\frac{\text{Cu. Ft.}}{100} = \text{GPM}$$

For example a fire in a floor 30 ft wide x 60 ft. long x 10 ft. high would require

$$\frac{18000 \text{ Cu. Ft.}}{100} = 180 \text{ GPM}$$

or a minimum of 2 1-1/2 inch lines for extinguishment.

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182 Ref:. Fire Stream Practices IFSTA, #105 pp. 131-135 Ref. p. 179 4-8 Fire Streams 4-8.1	STREAMS AT POINT OF ORIGIN This flow is adequate to control the fire if it is properly distributed in the area. The number and size of lines used to provide and distribute this flow will be dependent on the shape and points of access in the building involved as well as available manpower and equipment. The rate of flow formula gives the officer information upon which he can make tactical decisions and should be considered in any pre-fire planning. When the rate of flow is near the suggested formula and distribution is good, blackout of the fire should occur in about 30 seconds. At this time total application should be stopped and subsequent short applications in selected spots should be made with straight streams only to avoid upsetting steam blankets and air currents in other parts of the area. If the rate of application is somewhat higher than the suggested rate, blackout or knockdown will occur quicker and TOTAL FLOW SHOULD BE STOPPED EARLIER. If the fire is attacked within a few minutes after total involvement, one knockdown will usually hold until overhaul is accomplished. If the fire has been burning long enough to accumulate a substantial amount of coals and deep-seated burning, the fire may flash-back shortly after shut down, and additional full flow applications may need to be made before overhaul.
4-8 Fire Streams 4-8.8 Ref. p. 179	OBSERVABLE RESULTS Some observable results of the proper application of a fire stream are: .. Reduction of Heat ..Reduction of Smoke ..Reduction of Visible Flame ..Creation of Steam

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182 Ref: Fire Stream Practices IFSTA, #105 pp. 51-53 Ref. p. 179 4-8 Fire Streams 4-8.6	SPECIAL STREAM NOZZLES Nozzles which are designed for special purposes fulfill a specific need. The degree to which such nozzles are needed in the fire service depends upon the particular situation that exists or upon the particular fuel that has set up the situation. The widespread use of: ...hazardous industrial processes ...storage and transportation of flammable liquids ...testing of aviation fuel and engines and ...the construction of buildings in general are some of the activities that have increased the demand for special purpose nozzles for fire fighting. Special Purpose Nozzles: Puncture Nozzle - for penetrating into hidden spaces, walls, partitions, etc. Foam Nozzle - used for shaping and delivering foam extinguishing agents. High Pressure Fog Nozzle - generally used at pressures 600 psi. Adjustable Fog Nozzle - can provide short and long reach fog patterns (narrow or wide) Fixed Pattern Fog Nozzle - Generally short reach fog pattern Cellar or Distributor Nozzle - has a head which rotates by the pressure of the water emmitted from a number of angular orfices.
5-4 Fire Streams 5-4.1 Refer to Handout #2	
4-8 Fire Streams 4-8.7	FOAM The first foam liquid was developed by Sweden in 1935. This liquid was the first means of producing foam by mechanically injecting air into the solution rather than a chemical reaction.

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182

Ref: Fire Stream Practices IFSTA, #105 pp. 179-183

Ref. p. 179

4-8 Fire Streams

4-8.7

FOAM

Because of the lighter foam and a bubble containing air instead of co2 approximately three times the rate of application was required.

The expansion rate was about 20 to 1 and was called high expansion foam.

MECHANICAL FOAM

At or about the beginning of World War II, a protein base foam was developed.

This foam is also known as:

.. mechanical foam

..air foam

or

..low expansion foam.

The base for this foam concentrate is hyrolyzed protein.

The object was to get a foam that would :

...hold as much water as possible without breaking down

...be fluid enough to flow

...give quick coverage

...resist heat and flame.

The next development in the field was a penetrant base foam.

This foam does not have the stability of chemical or protein base foams but, because of its detergent nature, it has advantages for fire department use.

When applied through a fog nozzle at an expansion of approximately 10 to 1, an immediate foam blanket is produced for extinguishing flammable liquid fires.

As the foam breaks down, a "wet water" and emulsion is formed on the surface of flammable liquids.

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA,#200 pp. 161-182

Ref: Fire Stream Practices IFSTA, #105 pp. 179-183

4-8 Fire Streams

4-8.7

Ref. P. 180

FOAM

ULTRA HIGH EXPANSION FOAM

One recent development in the foam field is what might be called Ultra High Expansion Foam.

The use of forced air through screens and grids with a foam concentrate added to the water at the required percentage, enables a foam with expansions beyween 100 and 1,200 to 1 to be produced.

The forced air is introduced either by mechanical fans or by entraining air into the fog pattern.

Since the ratio of water to air is so low and the foam is so light the use of this type of foam in the open is not always satisfactory.

The pressure developed by these fans is very little and since this foam approaches the point of no longer being a liquid the height and distance it can be pushed is definitely limited.

Although the use of this type of foam is somewhat limited, there are some definite points established that must be considered.

A more thorough pre-fire planning job must be done to establish locations where Ultra High Expansion Foam can be applied.

REMEMBER; since this foam is being induced at a very high rate of displacement;

..allowance must be made for the escape of an equivalent amount of air.

Also

..that UHE foam is very dry and stiff and has a tendency to form pockets in which fire can continue to burn

And

..that burning will break down the surrounding foam to acquire the necessary oxygen for continued burning.

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182

Ref: Fire Stream Practices IFSTA, #105 pp. 179-183

4-8 Fire Streams

4-8.7

Ref. p. 180

FOAM

AQUEOUS FILM FORMING FOAM

Another recent development is fluorocarbon and fluoroprotein base foam.

These agents are classified as:

..Aqueous Film Forming Foam (AFFF)

These foams have been proven very effective when applied in a combination attack with dry chemical.

One feature of this type of foam is its vapor sealing barrier.

Manufacturer's recommendations concerning required percentage of mixture and type of nozzles to use for application should be followed.

Ref. p. 181

APPLICATION

As in all fire fighting the development of a good technique of applying a foam blanket requires much training and practice.

Since there is a definite aging and deterioration of foam concentrates, a program should be set up to use the oldest foam for training with a definite schedule of replacing the foam stock over a period of time.

By using one-third of a foam stock annually and replacing it with new foam, a stock of foam liquid over 3 years old can be avoided.

Laboratory tests on mechanical or protein foams are run at a rate of application of one gallon per minute water rate expanded to the normal 10 to 1 expansion, per square foot of burning surface of flammable liquid.

This is a good rate of application for practical purposes.

This means;

..with a 60 gpm nozzle, a fire in a normal hydocarbon fire of 600 square feet should be controlled.

..the rate of application of alcohol foams on alcohol fires is normally about twice this amount

And that some of the other surfactants require a slightly higher than one gallon per minute per square foot application.

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182

Ref: Fire Stream Practices IFSTA, #105 pp. 179-183

Ref. p. 181

4-8 Fire Streams

4-8.7

FOAM

APPLICATION

When fighting normal interior fires, the rate of foam application is very important.

WITH A LIMITED WATER SUPPLY A MORE RAPID RATE OF APPLICATIO IS OFTEN BETTER THAN EXTENDING THE TIME OF APPLICATION WITH SMALLER RATE OF APPLICATION.

The most successful method of applying foam to a liquid surface is to bounce the stream off a solid surface.

If the fire is a spill on a level surface, the stream should be directed at the ground in front of the fire to start a blanket of foam.

While sweeping the stream the width of the fire the fire fighter handling the nozzle begins to raise the stream to push the blanket over the surface.

NOTE: DONOT apply the stream directly into existing foam and thus blow foam from the surface.

The movement of the nozzle should be SLOW and DELIBERATE.

Direct the stream to the side until foam appears and then turn it to the fire.

If foam production should stop while in the process of extinguishing a fire, IMMEDIATELY remove the stream from the foam blanket so as not to wash it away.

Always use the maximum raech of the stream and let the foam do the work.

If the fire is in a tank or located so that the method just discussed cannot be used:

..the stream should be directed against the far inner side of the tank or other obstacle

..this uses the inside wall of the tank or other obstacles as splash boards which permits the foam to form a blanket to slide down and form across the surface.

.. DO NOT attempt to lob or drop the foam on the surface.

This method is very ineffective since the foam must fall through the heat where it will break up and fall on the surface in a rather scattered form.

Normally, the foam blanket should be formed about 3 inches thick.

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182

Ref: Fire Stream Practices IFSTA, #105 pp. 179-183

Ref. p. 181

4-8 Fire Streams

4-8.7

FOAM

EQUIPMENT

VENTURI TYPE PICKUP NOZZLE

Although the Venturi type pickup nozzle was the earliest method of applying mechanical foam, it is the most common method in use today.

This is a relatively simple device:

...water under pressure passes through an orfice, past an opening, through another orfice which causes a low pressure area in the opening

...atmospheric pressure then forces the foam liquid up through the pickup tube and into the opening

...the foam is mixed into the water stream

...the amount of foam concentrate passing into the stream is metered by an orfice in the pickup tube.

These nozzles are made in different ways:

...some are set for a definite proportion

WHILE

...others can be cahnged to be used with different percentage of concentrates

These foam nozzles also use the Venturi principle for mechanical expansion to the resultant foam.

...the orfices in the nozzle are directed past an external opening in the nozzle

...then against the barrel of the nozzle which pulls air through the external opening and into the stream.

This action creates the foam bubbles in the discharge tube of the nozzle.

EDUCTORS

Eductors, or as they are sometimes called proportioners, also operate on the Venturi principle.

They function exactly like the pickup nozzle, except the eductor is used in the hose line.

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182

Ref: Fire Stream Practices IFSTA, #105 pp. 179-183

Ref. p. 181

4-8 Fire Streams

4-8.7

Ref. p. 182

FOAM

EQUIPMENT

EDUCTORS

Eductors are normally at the pump rather than at the end of the line.

With protein or mechanical foam, 3 percent or 6 percent concentrate, a foam nozzle must be used to mechanically expand the foam for application to the fire.

Foam eductors and nozzles should be considered as systems since they are designed as such.

An eductor is designed to pass so much water at a definite pressure and the nozzle must pass the same amount of water at a pressure it is designed to operate.

When using these systems careful attention should be paid to the manufacturer's recommendations as to pressure, length of line and nozzle to be used.

With both of the above methods of inducing the foam concentrate one is depending upon the accurate movement of water and foam liquids through definite orfices so care must be taken to maintain all equipment in top condition:

..keep it clean and free from corrosion

..thoroughly wash all equipment after use

..keep booster tank water uncontaminated

The use of a water soluble oil in booster tanks to prevent corrosion will make the water unfit for use in foam production.

Only a few parts per million of oil contamination in the wat used for foam will be detrimental to the foaming properties and stability of the foam.

AROUND THE PUMP PROPORTIONER

The around-the-pump proportioner uses the eductor or Venturi principle but operates on a differential between the discharge and intake side of the pump.

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Essentials of Fire Fighting, IFSTA, #200 pp. 161-182 Ref: Fire Stream Practices IFSTA, #105 pp. 179-183 Ref. p. 182 4-8 Fire Streams 4-8.7	FOAM EQUIPMENT AROUND THE PUMP PROPORTIONER Using this system requires: ....pumping mixed foam and water through the fire pump ....all lines are then charged with foam ....the nozzle size or length of line is not as critical as with the eductor ....intake pressure at the pump must be maintained at less than 10 psi while operating the around-the-pump-proportioner ....the foam lines in the system must be kept clean and the fire pump thoroughly flushed AFTER USE. Manufacturer's recommendations for pressures and metering valve settings for the nozzle discharge rate should be followed.
Ref: Fire Stream Practices IFSTA, #105 pp. 22-23 Refer to Handout #6	FOR YOUR SAFETY CONDUCTIVITY OF FIRE STREAMS The table contained in these handouts applies to fresh water. Sea or salty water or water base extinguishing agent may have such high electrical conductivity that no rule can be applied for a reasonable safe distance. If it becomes necessary to use water known to have a high electrical conductivity, a broken stream should be used with EXTREME CAUTION. The distances given in the table in the handouts are minimum and are considered safe under NORMAL CIRCUMSTANCES A study of the table will indicate that, when a firefighter either intentionally or unintentionally directs water on a charged conductor, the use of a fog type nozzle is safer.

UNIT QUIZ

1. List three major purposes of fire streams:

   a. _____

   _____

   b. _____

   _____

   c. _____

   _____

2. Fill in the following characteristics of water:

   a. freezing point _____degrees

   b. boiling point _____degrees

   c. 1 gallon _____ pounds

   d. 1 cubic foot _____ gallons

3. List three advantages of water:

   a. _____

   _____

   b. _____

   _____

   c. _____

   _____

4. A British Thermal Unit (BTU) is defined as the amount of heat required to raise _____pound of water _____ degrees Farenheit.

5. Spray (fog) streams are generally more effective at absorbing heat than straight streams because they:

   (Circle the letter in front of the correct answer)

   a. have a lower forward velocity

   b. are usually developed at higher nozzle pressures

   c. expose greater surface area to the fire

   d. develop large volumes of steam

6. The expansion rate of water when converted to steam at 212 degrees F., is _____ to 1.

7. Fire stream requirements are primarily determined by the nature of the _____ _____ .

8. List the three types of streams produced by various nozzles:

   a._____

   b._____

   c._____

9. The term static pressure is understood to mean:

   (Circle the letter in front of the correct answer)

   a. stored potential energy that is available to force water through pipes, fire hose, and adapters.

   b. that part of the total available pressure that is not used to overcome friction or gravity.

   c. the pressure which is normally found on a water system during normal consumption demands.

   d. the forward velocity at a discharge opening while water is flowing.

10. What do the letters gpm stand for ? _____

11. What do the letters psi stand for ? _____

12. What is friction loss ?

_____

_____

13. Fill in the blanks for the approximate flows from the following straight stream nozzles:

   1" tip at 50 psi _____ gpm

   1-1/8" tip at 50 psi ____gpm

   1-1/4" tip at 50 psi ____gpm

14. State the flows for the avareage handline fog nozzles:

   3/4" or 1" at 100 psi ____gpm

   1-1/2" at 100 psi ____gpm

   2-1/2" at 100 psi ____gpm

ANSWER KEY

1. Apply water stream directly to the burning material

   Reduce high atmospheric temperatures and absorb and/or disperse hot smoke and gases from a heated area in a confined space.

   Reduce the temperature over an open fire and thus permit a closer proximity with hand hose lines to effect extinguishment.

   Protect firefighters and property from heat through the use of fire streams as a water curtain.

2. a. 32 degrees

   b. 212 degrees

   c. 8.33 pounds

   d. 7.48 gallons

3. a. Greater heat absorbing capacity than other common extenguishing agents

   b. A relatively large amount of heat is required to change water into steam.

   c. The greater the surface area of the water that is exposed the more rapidly heat will be absorbed.

   d. Water is relatively inexpensive.

4. one one

5. c.

6. 1700

7. Burning material.

8. Solid
   Broken
   Fog (Spray)

9. a.

10. Gallons Per Minute

11. Pounds Per Square Inch

12. That part of the total pressure that is used to overcome friction while forcing water through pipe, fittings, fire hose, and adapters.

13. 200
    250
    300

14. 12 to 32

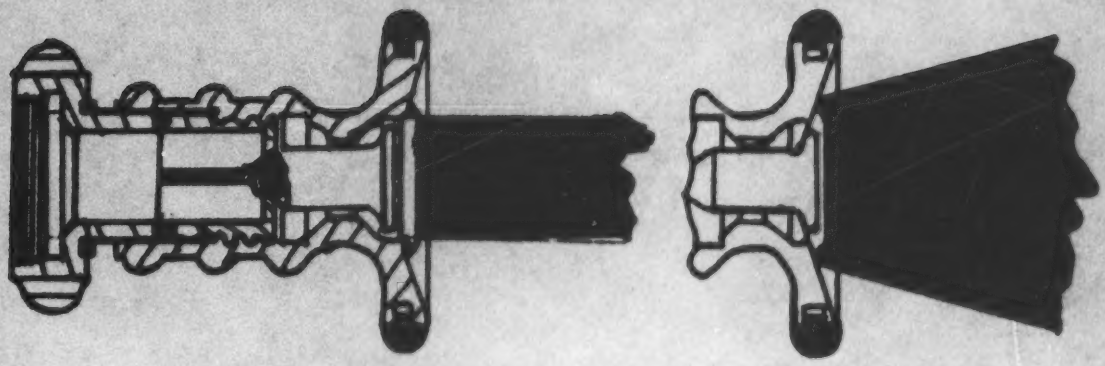
    30 to 125

    120 - 350

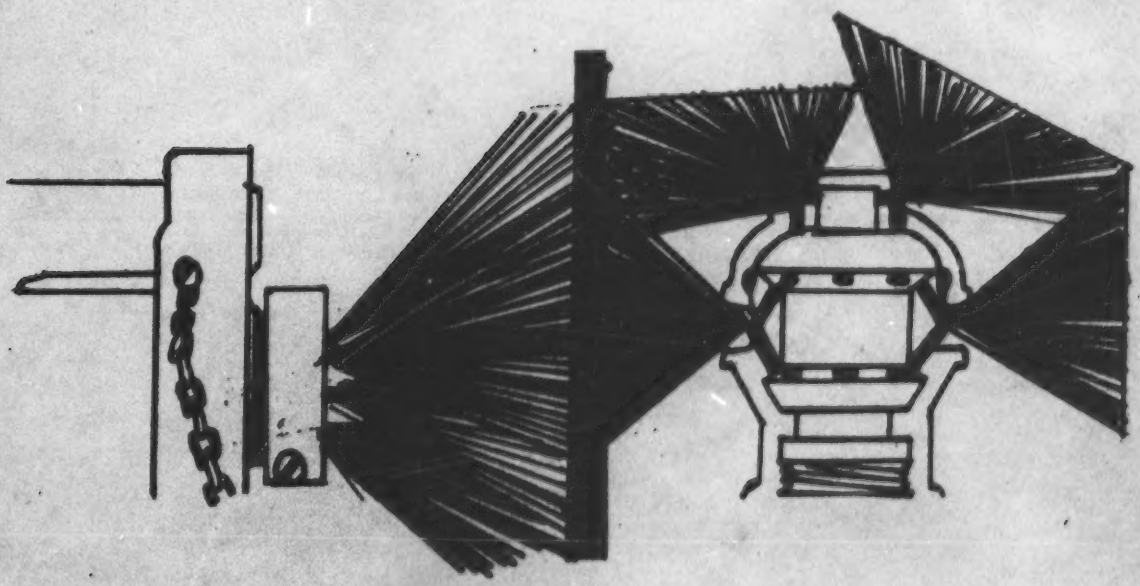
THE FOLLOWING TABLE SHOWS STANDARD DIAMETERS OF RUBBER-LINED FIRE HOSE IDENTIFIED WITH FLOWS WHICH THEY ARE CAPABLE OF CARRYING WITHOUT EXCESSIVE FRICTION LOSSES WHEN HOSE LENGTHS DO NOT EXCEED 600 FEET.

NOMINAL HOSE DIAMETER IN INCHES	MAXIMUM EFFICIENT WATER CAPACITY US GPM
1	30
1-1/2	100
2-1/2	300
2-3/4	400
3	500
3-1/2	750
4	1000
5	1700
6	2500

THE PERIPHERY DEFLECTED STREAM



THE IMPINGING DEFLECTED STREAM



EFFECTIVE REACH OF SOLID FIRE STREAMS

Showing the distance in feet from the nozzle at which streams will do effective work with a moderate wind blowing. With a strong wind the reach is greatly reduced.

	SIZE OF NOZZLE									
NOZZLE	1-inch		1-1/8 inch		1-1/4 inch		1-3/8 inch		1-1/2 inch	
PRESSURE	VERTICAL	HORIZONTAL	VERTICAL	HORIZONTAL	VERTICAL	HORIZONTAL	VERTICAL	HORIZONTAL	VERTICAL	HORIZ.
20	35	37	36	38	36	39	36	40	37	42
25	43	42	44	44	45	46	45	47	46	49
30	51	47	52	50	52	52	53	54	54	56
35	58	51	59	54	59	58	60	59	62	62
40	64	55	65	59	65	62	66	64	69	66
45	69	58	70	63	70	66	72	68	74	71
50	73	61	75	66	75	69	77	72	79	75
55	76	64	79	69	80	72	81	75	83	78
60	79	67	83	72	84	75	85	77	87	80
65	82	70	86	75	87	78	88	79	90	82
70	85	72	88	77	90	80	91	82	92	84
75	87	74	90	79	92	82	93	84	94	86
80	89	76	92	81	94	84	95	86	96	88
85	91	78	94	83	96	87	97	88	98	90
90	92	80	96	85	98	89	99	90	100	91

NOTE: Nozzle pressures are as indicated by Pitot tube. The horizontal and vertical distances are based on experiments by Mr. John R. Freeman, Transactions Am. Soc. C.E. Vol. XXI.

ANALYSIS OF THE EXTINGUISHMENT OF A CONFINED STRUCTURAL FIRE

PHASE	CONDITIONS	REQUIREMENTS TO EXTINGUISH	METHOD
1st	Beginning fire. 20% oxygen content of atmosphere. Accelerating heat generation according to development of fire. Considerable smoke in reverse proportion to heat generation Destruction limited to immediate fire area	Entrance and direct application of extinguishing agent. Personal protection if needed.	Make entrance. Locate fire. Apply extinguishing agent at base of fire. Protect self with protective breathing equipment. ventilate at natural openings if needed.
2nd	Flame production. Major involvement. Entrance difficult because of heat. Oxygen reduction 21-15% or less. Rapid heat generation with highest temperatures at ceiling. High convection of heated gases and air. Limited smoke production, increasing as flame decreases. Increasing atmospheric pressure within space. Rapid destruction.	Reduction of room temperatures to 300 degrees or less, Entrance and direct application of extinguishing agent to remaining fire. Personal protection if needed.	1. Locate area of major involvement. 2. Determine point or points at which application is to be made. 3. Make opening, if needed, small as possible for application of water fog. 4. Assume position so that nozzle will not be involved with hot smoke and condensing steam. 5. Apply fog into upper level to meet space requirements. -If applied at upper level use short reach fog. -If applied at lower level use long-reach fog and direct into upper level. The order of expulsion due to displacement will be: 1st Smoke 2nd Smoke and condensing steam 3rd Condensing steam. 6. Continue application of fog without interruption until decrease of condensing steam is noticed. 7. Enter and extinguish remaining fires and spot fires. 8. Protect self if necessary with breathing equipment and heavy clothing.
3rd	Smoldering fire. Oxygen below 15%. Convection ceased and stratification of temperatures, highest at upper level. General decreasing of temperatures due to lowering of heat generation and heat losses. Intense smoke production. Serious accumulation of carbon monoixde gas. Chance for atmospheric breathing. Possibility of smoke explosion if air is admitted.	Reduction of temperature Displacement of smoke and gases with steam to make space livable and eliminate chance for explosion. Entrance and direct application of extinguishing agent. Personal protection if needed.	

AVENUES OF FIRE SPREAD

HORIZONTAL EXTENSION

...Through wall openings by direct flame contact or by convected air currents.

...Through open space by radiated heat or by convected air currents.

...Through corridors, halls, or passageways by convected air currents, radiation and direct flame contact.

...In all directions by explosion or flash burning of fire gases, flammable vapors, or dust.

...Through walls and interior partitions by direct flame contact.

...Through walls by conduction of heat through beams, pipes, ducts, or other objects that extend through walls.

VERTICAL EXTENSION

...Through stairwells, elevators and shafts by direct flame contact or by convected air currents.

...Through partitions and walls and upward between the walls by direct flame contact and convected air currents.

...Through windows or other exterior openings by convection into upper floors.

...Through ceilings and floors by conduction of heat through beams, pipes or other objects that extend from floor to floor.

...Through ceilings and floors by direct flame contact.

DOWNWARD EXTENSION

...Through floors and ceilings by direct flame contact.

...Through floor and ceiling openings where sparks and burning material fall through beams, pipes and other objects that extend from floor to floor.

...By the collapse of floors and roofs.

SAFETY REQUIREMENTS ELECTRICAL FIRES

VOLTAGE	SAFE DISTANCE 1-1/8" TIP	SAFE DISTANCE 1-1/2" TIP
1,100	6 feet	9 feet
2,200	11 feet	16 feet
3,300	15 feet	22 feet
5,500	18 feet	27 feet
6,600	19 feet	29 feet
11,000	20 feet	30 feet
22,000	25 feet	33 feet
33,000	30 feet	40 feet

VOLTAGE	SAFE DISTANCE FOG NOZZLE	SAFE DISTANCE FOG NOZZLE
15,000	1/2 foot	(6 inches)
25,000	2/3 foot	(8 inches)
46,000	1-1/4 feet	(15 inches)
92,000	2-1/2 feet	(30 inches)
138,000	3-2/3 feet	(44 inches)
161,000	4-1/3 feet	(52 inches)
230,000	6-1/3 feet	(76 inches)
345,000	10 feet	(120 inches)

FLOWS FROM HAND LINE STRAIGHT STREAM AND FOG NOZZLES

Straight Stream At 50 PSI

3/4 inch	100 gpm
7/8 inch	150 gpm
1 inch	200 gpm
1-1/8 inch	250 gpm
1-1/4 inch	300 gpm

Fog Nozzles at 100 psi

3/4 or 1 inch	12 to 32 gpm
1-1/2 inch	30 to 125 gpm
2-1/2 inch	120 to 350 gpm